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National Air Pollutant Emission Estimates, 1940-1983

Monitoring and Data Analysis Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
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ABSTRACT

This report presents estimates of trends in nationwide air pollutant emissions for the six major pollutants: particulates, sulfur oxides, nitrogen oxides, volatile organic compounds carbon monoxide and lead. Estimates are presented for each year from 1940 through 1983. Emission estimates are broken down according to major classifications of air pollution sources. A short analysis of trends is given, along with a discussion of methods used to develop the data.

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NATIONAL AIR POLLUTANT EMISSION ESTIMATES

1940-1983

1. SUMMARY

The primary objectives of this publication are to provide current estimates of nationwide emissions for six major pollutants: particulate matter (PM), sulfur oxides (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC), carbon monoxide (CO) and lead (Pb). Estimates are presented for 1940, 1950, and 1960 to give an historical perspective of national air pollutant emissions, and for 1970 through 1983 as an indication of recent trends. These data entirely replace those published earlier for 1940-1982 in EPA report National Air Pollutant Emission Estimates, 1940-1982 (EPA-450/4-83-024). Because of modifications in methodology and use of more refined emission factors, data from this report should not be compared with data in the earlier report.

Reporting of emissions on a nationwide basis, while useful as a general indicator of pollutant levels, has definite limitations. National totals or averages are not the best guide for estimating trends for particular localities. Yet, it is important that some criteria be established for measurement of national progress in the control of air pollutant emissions. The emission estimates presented herein represent calculated estimates based on standard emission inventory procedures. Since these data are estimates only and do not represent the results of any program for the measurement of actual emissions, their accuracy is somewhat limited. Similarly, it would not necessarily be expected that these emission estimates would be in agreement with emission estimates derived through a different emission inventory procedure. The principal objective of compiling these data is to identify probable overall changes in emissions on a national scale. It should be recognized that these estimated national trends in emissions may not be representative of local trends in emissions or air quality.

TABLE 1

SUMMARY OF NATIONAL EMISSION ESTIMATES

Units of Measurement	Year	Particulates	Sulfur Oxides	Nitrogen Oxides	Volatile Organics	Carbon Monoxide	Lead
PM, SO_2 NO_x, VOC, CO:							
Teragrams/Year	1940	22.4	18.0	6.7	17.7	79.4	NA
(10^6 metric tons/year)	1950	24.2	20.3	9.3	20.3	84.8	NA
	1960	20.9	20.0	12.8	23.3	87.5	NA
Lead (Pb):	1970	18.0	28.2	18.1	27.0	98.3	203.8
	1971	16.7	26.8	18.5	26.3	96.3	220.8
Gigagrams/Year	1972	15.0	27.4	19.7	26.3	93.8	231.7
(10^3 metric ton/year)	1973	13.9	28.7	20.2	25.7	89.5	202.7
	1974	12.2	27.0	19.6	24.1	84.6	162.1
	1975	10.3	25.6	19.1	22.7	80.5	147.0
	1976	9.6	26.2	20.3	23.8	85.3	153.1
	1977	9.0	26.3	20.9	23.6	81.1	141.2
	1978	8.9	24.5	21.0	24.2	80.6	127.9
	1979	8.8	24.5	21.1	23.5	77.4	108.7
	1980	8.3	23.2	20.3	22.3	75.0	70.6
	1981	7.7	22.3	20.5	21.0	72.3	55.9
	1982	6.8	21.3	19.6	19.4	66.1	54.4
	1983	6.9	20.8	19.4	19.9	67.6	46.9
PM, SO_2, NO_x, VOC, CO:							
(10^6 short tons/year)	1940	24.7	19.8	7.4	19.5	87.5	NA
	1950	26.7	22.4	10.3	22.4	93.5	NA
Lead (Pb):	1960	23.0	22.0	14.1	25.7	96.5	NA
	1970	19.8	31.1	20.0	29.8	108.4	224.6
(10^3 short ton/year)	1971	18.4	29.5	20.4	29.0	106.2	243.4
	1972	16.5	30.2	21.7	29.0	103.4	255.4
	1973	15.3	31.6	22.3	28.3	98.7	223.4
	1974	13.4	29.8	21.6	26.6	93.3	178.7
	1975	11.4	28.2	21.1	25.0	88.7	162.0
	1976	10.6	28.9	22.4	26.2	94.0	168.8
	1977	9.9	29.0	23.0	26.0	89.4	155.6
	1978	9.8	27.0	23.1	26.7	88.8	141.0
	1979	9.7	27.0	23.3	25.9	85.3	119.8
	1980	9.1	25.6	22.4	24.6	82.7	77.8
	1981	8.5	24.6	22.6	23.1	79.7	61.6
	1982	7.5	23.5	21.6	21.4	72.9	60.0
	1983	7.6	22.9	21.4	21.9	74.5	51.7
Change 1940-1983		-69%	+16%	+190%	+12%	-15%	NA
Change 1970-1983		-62%	-26%	+7%	-26%	-31%	-77%
Change 1975-1983		-33%	-19%	+2%	-12%	-16%	-68%

2. NATIONWIDE EMISSION TRENDS, 1940-1983

Table 1 gives a summary of total national emission estimates for 1940-1983. Tables 2 through 12 present summaries for each year according to the five major categories of sources: transportation, stationary source fuel combustion, industrial processes, solid waste disposal, and miscellaneous sources. More detailed breakdowns of emissions for 1970 through 1983 are given in Tables 13 through 17 for transportation, Tables 18 through 22 for stationary source fuel combustion, and in Tables 23 through 28 for industrial processes.

The Standard Industrial Classifications (SIC) are shown for each process category in the industrial process tables. These designations are not intended to represent the complete emissions for all SIC categories and serve only to identify and classify the industrial process shown.

In all tables, data are reported in metric units, either as teragrams (10^{12} grams) or gigagrams (10^{9} grams) per year. One teragram equals approximately 1.1×10^{6} short tons and one gigagram equals approximately 1.1×10^{3} short tons.

2.1 Particulates (PM)

Particulate emissions result primarily from industrial processes and from fuel combustion in stationary sources. For 1940 and 1950, emissions from transportation (coal combustion by railroads) and miscellaneous sources (forest fires) were also significant. Emissions from fuel combustion and industrial processes did not change substantially from 1940 to 1970. Since 1970, emissions from these categories have been substantially reduced as the result of installation of air pollution control equipment. Particulate emissions from transportation decreased substantially from 1940 to 1960 as the result of the obsolescence of coal-burning railroad locomotives. From 1960 to 1983, particulates from transportation increased due to increased travel by highway motor vehicles. Miscellaneous source emissions decreased substantially from 1940 to 1970, primarily due to a major reduction in the acreage burned by forest wildfires. Solid waste emissions increased from 1940 to 1970, but declined substantially to 1983 as the result of air pollution regulations prohibiting or limiting the burning of solid waste.

2.2 Sulfur Oxides (SO_2)

Sulfur oxide emissions occur mostly from stationary source fuel combustion and to some extent, from industrial processes. Sulfur oxide emissions from combustion of coal by railroad locomotives were also significant in 1940 and 1950. Emissions from solid waste disposal and miscellaneous sources have always been minor. Emissions from stationary source fuel combustion increased greatly from 1940 to

From 1970 to 1983, emissions from fuel combustion have decreased slightly. During this time period, fuel combustion, particularly of sulfur-bearing coal and oil, continued to increase, but the average sulfur contents of fuels decreased and a limited number of pollution control systems (flue gas desulfurization) were installed. Emissions from industrial processes increased from 1940 to 1970 reflecting increased industrial production. From 1970 to 1983, industrial process emissions decreased primarily due to control measures by primary nonferrous smelters and sulfuric acid plants.

2.3 Nitrogen Oxides (NO_x)

Nitrogen oxide emissions are produced largely by stationary source fuel combustion and transportation sources. Emissions have steadily increased over the period from 1940 to 1970 as the result of increased fuel combustion. From 1970 to 1983, the size of the increase was reduced somewhat by controls installed on highway motor vehicles and to a lesser extent by controls on coal-fired electric utility boilers. Since 1979, NO_x emissions have actually decreased slightly. Nitrogen oxide emissions by industrial processes increased from 1940 to 1970, but have remained about constant since then.

2.4 Volatile Organic Compounds (VOC)

The largest sources of VOC emissions are transportation sources and industrial processes. Miscellaneous sources, primarily forest wildfires and non-industrial consumption of organic solvents, also contribute significantly to total VOC emissions. Emissions from stationary source fuel combustion and solid waste disposal are relatively small. Transportation source emissions increased greatly from 1940 to 1970, primarily as the result of increased travel by highway motor vehicles. Since 1970, air pollution controls installed on motor vehicles have been effective in reducing VOC emissions. Industrial process emissions have increased through the late 70's, generally reflecting increased levels of industrial production. Controls installed on industrial processes since 1970 have had a modest effect in preventing additional increases in VOC emissions. Since 1979, VOC emissions from industrial processes have decreased. This reflects both the installation of controls and a lower level of industrial output during these years. Emissions from stationary source combustion declined from 1940 through the mid-1970's and then increased to 1983, reflecting primarily the trend in residential wood combustion.

2.5 Carbon Monoxide (CO)

Transportation sources are the largest emitters of carbon monoxide. Major increases in emissions occurred from 1940 to 1970 as the result of increased motor vehicle travel. From 1970 to 1983, transportation emissions decreased as the result of highway vehicle emission controls.

despite continued increases in highway vehicle travel. Emissions from stationary source fuel combustion have declined from 1940 through the mid-1970's and then increased slightly to 1983.

Prior to 1970, residential coal and wood combustion contributed significantly to CO emissions. However, as residential use of coal has been replaced by other fuels, residential emissions have declined. Beginning in the late 1970's, residential combustion of wood has increased, however, and as a result CO emissions from residential fuel combustion increased. Carbon monoxide emissions from industrial processes increased from 1940 to 1950 but have declined somewhat since then. The decline is due largely to the obsolesence of a few high-polluting industrial processes such as carbon black manufacture by the channel process and limited installation of control equipment on other processes. These factors have been significant enough to offset growth in industrial production which would otherwise have caused a net increase in emissions. Carbon monoxide emissions from solid waste disposal increased from 1940 to 1970, but have subsequently declined as the result of air pollution control efforts. Substantial emissions of carbon monoxide from forest fires occurred in 1940. In later years, these emissions have been much smaller due to improved fire prevention efforts and more effective suppression of wildfires.

2.6 Lead (Pb)

Lead emissions result primarily from transportation sources and industrial processes. Emissions for lead were not computed before 1970 because of missing data, especially for transportation sources. From 1970 to 1974, the transportation emissions varied based on the amount of gasoline consumed and the average lead content. From 1975 to 1983, transportation emissions decreased as a result of the conversion to unleaded gasoline. Emissions from industrial processes have declined from 1970 to 1983 as the result of installation of air pollution control equipment.

TABLE 2

1940-1970 SUMMARY OF ESTIMATED
EMISSIONS OF PARTICULATES
(TERAGRAMS/YEAR)

Source Category	1940	1950	1960	1970
Transportation				
Highway Vehicles	0.2	0.3	0.6	0.9
Aircraft	0.0	0.0	0.0	0.1
Railroads	2.4	1.7	0.1	0.1
Vessels	0.1	0.1	0.0	0.0
Other Off-Highway	0.0	0.0	0.0	0.1
Transportation Total	2.7	2.1	0.7	1.2
Stationary Source Fuel Combustion				
Electric Utilities	1.3	2.0	2.8	2.3
Industrial	3.3	2.7	1.7	1.6
Commercial Institutional	0.4	0.5	0.1	0.1
Residential	2.1	1.5	0.9	0.5
Fuel Combustion Total	7.1	6.7	5.5	4.5
Industrial Processes				
Iron and Steel Mills	3.0	3.5	1.7	1.2
Primary Metal Smelting	0.6	0.6	0.5	0.5
Secondary metals	0.3	0.3	0.2	0.2
Mineral Products	1.7	2.6	3.4	2.6
Chemicals	0.3	0.4	0.3	0.2
Petroleum Refining	0.0	0.0	0.1	0.1
Wood Products	0.4	0.7	0.8	0.6
Food and Agriculture	0.8	0.8	0.9	0.8
Mining Operations	1.3	3.4	4.1	3.9
Industrial Processes Total	8.4	12.3	12.0	10.1
Solid Waste Disposal				
Incineration	0.3	0.3	0.4	0.4
Open Burning	0.2	0.3	0.5	0.7
Solid Waste Total	0.5	0.6	0.9	1.1
Miscellaneous				
Forest Fires	2.9	1.7	1.0	0.7
Other Burning	0.8	0.8	0.8	0.4
Misc. Total	3.7	2.5	1.8	1.1
Total of All Sources	22.4	24.2	20.9	18.0

NOTE: One teragram equals 10^{12} grams (10^{6} metric tons) or approximately 1.1×10^{6} short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 3

1940-1970 SUMMARY OF ESTIMATED
EMISSIONS OF SULFUR OXIDES
(TERAGRAMS/YEAR)

Source Category	1940	1950	1960	1970
Transportation				
Highway Vehicles	0.0	0.1	0.1	0.3
Aircraft	0.0	0.0	0.0	0.0
Railroads	2.7	2.0	0.2	0.1
Vessels	0.2	0.2	0.1	0.1
Other Off-Highway	0.0	0.0	0.0	0.1
Transportation Total	2.9	2.1	0.4	0.6
Stationary Source Fuel Combustion				
Electric Utilities	2.2	4.1	8.4	15.8
Industrial	5.5	5.2	3.5	4.1
Commercial Institutional	1.0	1.7	1.0	0.9
Residential	2.3	1.9	1.1	0.5
Fuel Combustion Total	11.0	12.9	14.0	21.3
Industrial Processes				
Primary Metal Smelting	2.5	2.8	3.0	3.6
Pulp Mills	0.1	0.1	0.1	0.1
Chemicals	0.2	0.4	0.4	0.6
Petroleum Refining	0.2	0.3	0.6	0.7
Iron & Steel	0.3	0.5	0.4	0.5
Secondary Metals	0.0	0.0	0.0	0.0
Mineral Products	0.3	0.5	0.5	0.6
Natural Gas Processing	0.0	0.0	0.1	0.1
Industrial Processes Total	3.6	4.6	5.1	6.2
Solid Waste Disposal				
Incineration	0.0	0.0	0.0	0.0
Open Burning	0.0	0.0	0.0	0.0
Solid Waste Total	0.0	0.0	0.0	0.0
Miscellaneous				
Forest Fires	0.0	0.0	0.0	0.0
Other Burning	0.5	0.5	0.5	0.1
Misc. Total	0.5	0.5	0.5	0.1
Total of All Sources	18.0	20.3	20.0	28.2

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 4

1940-1970 SUMMARY OF ESTIMATED
EMISSIONS OF NITROGEN OXIDES
(TERAGRAMS/YEAR)

Source Category	1940	1950	1960	1970
Transportation				
Highway Vehicles	1.3	2.1	3.6	6.0
Aircraft	0.0	0.0	0.0	0.1
Railroads	0.6	0.9	0.7	0.6
Vessels	0.1	0.1	0.1	0.1
Other Off-Highway	0.2	0.4	0.5	0.8
Transportation Total	2.2	3.5	4.9	7.6
Stationary Source Fuel Combustion				
Electric Utilities	0.6	1.2	2.3	4.5
Industrial	2.2	2.9	3.7	3.9
Commercial Institutional	0.2	0.3	0.3	0.3
Residential	0.3	0.3	0.4	0.4
Fuel Combustion Total	3.3	4.7	6.7	9.1
Industrial Processes				
Petroleum Refining	0.1	0.1	0.2	0.2
Chemicals	0.0	0.0	0.1	0.2
Iron and Steel Mills	0.0	0.1	0.1	0.1
Pulp Mills	0.0	0.0	0.0	0.0
Mineral Products	0.1	0.1	0.1	0.2
Industrial Processes Total	0.2	0.3	0.5	0.7
Solid Waste Disposal				
Incineration	0.0	0.1	0.1	0.1
Open Burning	0.1	0.1	0.2	0.3
Solid Waste Total	0.1	0.2	0.3	0.4
Miscellaneous				
Forest Fires	0.7	0.4	0.2	0.2
Other Burning	0.2	0.2	0.2	0.1
Misc. Total	0.9	0.6	0.4	0.3
Total of All Sources	6.7	9.3	12.8	18.1

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 5

1940-1970 SUMMARY OF ESTIMATED
EMISSIONS OF VOLATILE ORGANIC COMPOUNDS
(TERAGRAMS/YEAR)

Source Category	1940	1950	1960	1970
Transportation				
Highway Vehicles	4.5	6.8	10.0	11.1
Aircraft	0.0	0.1	0.2	0.2
Railroads	0.5	0.5	0.2	0.2
Vessels	0.0	0.1	0.2	0.3
Other Off-Highway	0.2	0.4	0.5	0.5
Transportation Total	5.2	7.9	11.1	12.3
Stationary Source Fuel Combustion				
Electric Utilities	0.0	0.0	0.0	0.0
Industrial	0.1	0.1	0.1	0.1
Commercial Institutional	0.0	0.0	0.0	0.0
Residential	3.8	2.5	1.5	0.8
Fuel Combustion Total	3.9	2.6	1.6	0.9
Industrial Processes				
Chemicals	0.8	1.2	1.1	1.6
Petroleum Refining	0.4	0.5	0.7	0.7
Iron and Steel Mills	0.1	0.1	0.1	0.1
Mineral Products	0.0	0.0	0.0	0.0
Food and Agriculture	0.1	0.1	0.2	0.2
Industrial Organic Solvent Use	1.0	2.1	2.4	4.0
Petroleum Product Production and Marketing	0.8	1.2	1.6	2.1
Industrial Processes Total	3.2	5.2	6.1	8.7
Solid Waste Disposal				
Incineration	0.4	0.4	0.5	0.5
Open Burning	0.5	0.6	0.9	1.3
Solid Waste Total	0.9	1.0	1.4	1.8
Miscellaneous				
Forest Fires	3.1	1.7	0.9	0.7
Other Burning	0.6	0.6	0.5	0.3
Misc. Organic Solvent Use	0.8	1.3	1.7	2.3
Misc. Total	4.5	3.6	3.1	3.3
Total of All Sources	17.7	20.3	23.3	27.0

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 6

1940-1970 SUMMARY OF ESTIMATED
EMISSIONS OF CARBON MONOXIDE
(TERAGRAMS/YEAR)

Source Category	1940	1950	1960	1970
Transportation				
Highway Vehicles	22.0	33.1	46.5	62.7
Aircraft	0.0	0.8	1.6	0.9
Railroads	3.7	2.8	0.3	0.3
Vessels	0.2	0.2	0.6	1.1
Other Off-Highway	3.4	6.7	8.0	6.8
Transportation Total	29.3	43.6	57.0	71.8
Stationary Source Fuel Combustion				
Electric Utilities	0.0	0.1	0.1	0.2
Industrial	0.4	0.5	0.6	0.7
Commercial Institutional	0.1	0.1	0.0	0.1
Residential	13.2	9.2	5.4	2.9
Fuel Combustion Total	13.7	9.9	6.1	3.9
Industrial Processes				
Chemicals	3.8	5.3	3.6	3.1
Petroleum Refining	0.2	2.4	2.8	2.0
Iron and Steel Mills	1.5	1.1	1.3	1.6
Primary Metal Smelting	0.0	0.1	0.3	0.6
Secondary Metals	1.0	1.4	1.0	1.1
Pulp Mills	0.1	0.2	0.3	0.6
Industrial Processes Total	6.6	10.5	9.3	9.0
Solid Waste Disposal				
Incineration	2.0	2.5	2.5	2.7
Open Burning	1.3	1.8	2.6	3.7
Solid Waste Total	3.3	4.3	5.1	6.4
Miscellaneous				
Forest Fires	22.8	12.8	6.7	5.1
Other Burning	3.7	3.7	3.3	2.1
Misc. Total	26.5	16.5	10.0	7.2
Total of All Sources	79.4	84.8	87.5	98.3

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 7

PARTICULATE
NATIONAL EMISSION ESTIMATES
(TERAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Transportation														
Highway Vehicles	0.9	0.9	1.0	1.1	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Aircraft	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Railroads	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Off-Highway	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transportation Total	1.2	1.2	1.3	1.4	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3
Stationary Source Fuel Combustion														
Electric Utilities	2.3	2.1	1.9	1.8	1.7	1.5	1.3	1.2	1.2	1.0	0.8	0.7	0.6	0.5
Industrial	1.6	1.2	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.5	0.5	0.5	0.4	0.4
Commercial Institutional	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residential	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0
Fuel Combustion Total	4.5	3.9	3.3	3.1	2.9	2.6	2.4	2.4	2.3	2.3	2.2	2.2	2.0	2.0
Industrial Processes	10.1	9.4	8.8	7.9	6.4	5.0	4.4	4.0	4.0	3.8	3.2	2.8	2.4	2.3
Solid Waste Disposal														
Incineration	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Open Burning	0.7	0.5	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Solid Waste Total	1.1	0.9	0.7	0.6	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Miscellaneous														
Forest Fires	0.7	0.9	0.7	0.7	0.8	0.6	0.9	0.7	0.7	0.8	1.0	0.8	0.6	0.8
Other burning	0.4	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Total	1.1	1.3	0.9	0.9	1.0	0.7	1.0	0.8	0.8	0.9	1.1	0.9	0.7	0.9
Total of All Sources	18.0	16.7	15.0	13.9	12.2	10.3	9.6	9.0	8.9	8.8	8.3	7.7	6.8	6.9

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 8

SULFUR OXIDE
NATIONAL EMISSION ESTIMATES
(TERAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Transportation														
Highway Vehicles	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5
Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Railroads	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vessels	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2
Other Off-Highway	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Transportation Total	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.8	0.9	0.9	0.8	0.8	0.9
Stationary Source Fuel Combustion														
Electric Utilities	15.8	15.5	15.8	17.2	16.6	16.6	17.1	17.2	15.8	16.0	15.5	14.7	14.2	14.0
Industrial	4.1	3.5	3.5	3.3	3.1	2.7	2.7	2.8	2.7	2.6	2.4	2.3	2.3	2.1
Commercial Institutional	0.9	0.9	0.9	0.9	0.8	0.7	0.8	0.8	0.8	0.6	0.7	0.6	0.6	0.5
Residential	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Fuel Combustion Total	21.3	20.3	20.5	21.7	20.8	20.3	20.9	21.1	19.6	19.4	18.8	17.8	17.3	16.8
Industrial Processes	6.2	5.8	6.2	6.3	5.6	4.7	4.6	4.4	4.1	4.2	3.5	3.7	3.2	3.1
Solid Waste Disposal														
Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Burning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid Waste Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous														
Forest Fires	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other burning	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Total	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total of All Sources	28.2	26.8	27.4	28.7	27.0	25.6	26.2	26.1	24.5	24.5	23.2	22.3	21.3	20.8

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 9

NITROGEN OXIDE
NATIONAL EMISSION ESTIMATES
(TERAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Transportation														
Highway Vehicles	6.0	6.4	7.1	7.5	7.1	7.1	7.4	7.6	7.6	7.4	7.2	7.4	7.0	7.0
Aircraft	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Railroads	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.7	0.7	0.6
Vessels	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.2
Other Off-Highway	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.0	0.9	0.9	0.9
Transportation Total	7.6	8.0	8.9	9.3	8.9	8.9	9.3	9.5	9.7	9.6	9.2	9.3	8.9	8.8
Stationary Source Fuel Combustion														
Electric Utilities	4.5	4.7	5.0	5.3	5.3	5.7	5.6	6.0	5.9	6.2	6.4	6.5	6.7	6.3
Industrial	3.9	3.8	3.9	3.9	3.7	3.4	3.7	3.7	3.7	3.6	3.0	3.0	3.0	2.8
Commercial Institutional	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2
Residential	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fuel Combustion Total	9.1	9.2	9.6	9.9	9.7	9.3	10.0	10.4	10.3	10.5	10.1	10.2	9.9	9.7
Industrial Processes	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6
Solid Waste Disposal														
Incineration	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Burning	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Solid Waste Total	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous														
Forest Fires	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2
Other burning	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Total	0.3	0.3	0.3	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2
Total of All Sources	18.1	18.5	19.7	20.2	19.6	19.1	20.1	20.9	21.0	21.1	20.5	20.5	19.6	19.4

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 10

VOLATILE ORGANIC [illegible]
NATIONAL EMISSION ESTIMATES
([illegible]/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Transportation														
Highway Vehicles	11.1	10.9	10.8	10.2	9.7	9.0	9.1	8.7	8.5	7.6	6.9	6.7	6.2	6.0
Aircraft	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Railroads	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vessels	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other Off-Highway	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4
Transportation Total	12.1	11.7	11.1	11.5	10.5	10.1	10.4	10.0	9.8	8.9	8.2	8.0	7.5	7.2
Stationary Source Fuel Combustion														
Electric Utilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industrial	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Commercial Institutional	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	1.9	2.0
Fuel Combustion Total	0.9	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.3	1.5	1.7	1.9	2.0	2.1
Industrial Processes	8.7	8.4	9.1	9.4	9.0	8.1	8.7	9.0	9.6	9.5	8.9	8.0	7.1	7.5
Solid Waste Disposal														
Incineration	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
Open Burning	1.3	1.0	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Solid Waste Total	1.8	1.5	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.6
Miscellaneous														
Forest Fires	0.7	0.9	0.7	0.6	0.7	0.5	0.9	0.7	0.7	0.8	0.9	0.8	0.6	0.8
Other burning	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Misc. Organic Solvent	2.3	2.2	2.3	2.2	2.1	1.9	1.9	1.9	1.9	2.0	1.9	1.6	1.5	1.6
Misc. Total	3.1	3.4	3.2	3.0	2.9	2.5	2.9	2.7	2.7	2.9	2.9	2.5	2.2	2.5
Total of All Sources	27.0	26.3	26.3	25.7	24.1	22.7	23.8	23.6	24.2	23.5	22.3	21.0	19.4	19.9

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 11

CARBON MONOXIDE
NATIONAL EMISSION ESTIMATES
(TERAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Transportation														
Highway Vehicles	62.7	61.7	62.1	59.7	55.1	54.7	56.4	53.4	52.6	48.7	45.3	44.7	41.1	41.2
Aircraft	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Railroads	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2
Vessels	1.1	1.2	1.1	1.1	1.1	1.4	1.4	1.4	1.5	1.6	1.4	1.6	1.6	1.6
Other Off-Highway	6.8	6.5	6.3	6.7	5.6	5.3	5.3	5.1	4.8	4.5	4.7	4.7	4.4	3.9
Transportation Total	71.8	70.5	71.1	68.3	63.2	62.8	64.3	61.1	60.8	55.9	52.7	51.6	48.1	47.7
Stationary Source Fuel Combustion														
Electric Utilities	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Industrial	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Commercial Institutional	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residential	2.9	2.7	2.5	2.3	2.4	2.7	3.0	3.3	3.8	4.5	5.2	5.3	5.7	6.0
Fuel Combustion Total	3.9	3.7	3.6	3.4	3.5	3.7	4.1	4.4	4.9	5.6	6.2	6.3	6.7	7.0
Industrial Processes	9.0	8.7	8.4	8.5	8.1	6.9	7.1	7.7	7.1	7.1	6.3	5.9	4.4	4.6
Solid Waste Disposal														
Incineration	2.7	2.3	2.2	2.1	1.9	1.8	1.5	1.5	1.4	1.3	1.2	1.2	1.1	1.1
Open Burning	3.7	2.7	2.1	1.7	1.5	1.3	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.9
Solid Waste Total	6.4	5.0	4.3	3.8	3.4	3.1	2.7	2.6	2.5	2.3	2.2	2.1	2.0	2.0
Miscellaneous														
Forest Fires	5.1	6.7	5.3	4.5	5.6	4.0	6.4	5.1	5.0	5.8	6.9	5.8	4.3	5.7
Other burning	1.1	1.7	1.2	1.0	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
Misc. Organic Solvent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Misc. Total	7.2	8.4	6.4	5.5	6.4	4.8	7.1	5.8	5.7	6.5	7.6	6.6	4.9	6.3
Total of All Sources	98.3	96.3	93.8	89.5	84.6	80.5	85.3	81.1	80.6	77.4	75.0	72.3	66.1	67.6

NOTE: One teragram equals 10^{12} grams (10^6 metric tons) or approximately 1.1×10^6 short tons. A value of zero indicates emissions of less than 50,000 metric tons.

TABLE 12

LEAD
NATIONAL EMISSION ESTIMATES
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Transportation														
Highway Vehicles	156.0	174.8	190.4	166.0	129.6	118.1	127.5	119.5	108.2	90.8	56.4	43.9	44.4	38.7
Off-Highway	7.6	7.8	7.6	6.3	4.7	4.5	4.9	4.7	4.2	3.8	3.0	2.5	2.5	2.0
Transportation Total	163.6	182.6	198.0	172.3	134.3	122.6	132.4	124.2	112.4	94.6	59.4	46.4	46.9	40.7
Stationary Source Fuel Combustion														
Electric Utilities	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Industrial	9.3	9.2	9.2	9.2	9.2	9.1	8.1	7.0	5.9	4.8	3.8	2.7	1.6	0.5
Commercial Institutional	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Combustion Total	9.6	9.5	9.4	9.4	9.4	9.3	8.3	7.2	6.1	4.9	3.9	2.8	1.7	0.6
Industrial Processes	23.9	22.5	18.6	15.6	13.3	10.3	8.1	5.7	5.4	5.2	3.6	3.0	2.7	2.5
Solid Waste Disposal	6.7	6.2	5.7	5.4	5.1	4.8	4.3	4.1	4.0	4.0	3.7	3.7	3.1	3.1
Total of All Sources	203.8	220.8	231.7	202.7	162.1	147.0	153.1	141.2	127.9	108.7	70.6	55.9	54.4	46.9

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons).

TABLE 13

PARTICULATE EMISSIONS FROM TRANSPORTATION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Highway Vehicles														
Gasoline-powered														
Passenger cars	610	640	670	690	670	680	680	670	670	620	570	540	560	550
Light trucks - 1	80	90	100	100	100	100	100	100	90	90	90	90	80	90
Light trucks - 2	20	20	30	30	30	30	40	50	60	70	70	70	70	60
Heavy duty vehicles	60	50	60	60	50	50	60	60	60	60	60	60	50	50
Motorcycles	4	5	6	7	8	8	8	8	8	8	7	5	4	4
Total - Gasoline	770	810	870	890	860	870	890	890	890	850	800	770	760	750
Diesel-powered														
Passenger cars	0	0	0	0	0	1	1	1	2	5	9	10	20	20
Light trucks	0	0	0	0	0	0	0	0	1	1	3	5	5	7
Heavy duty vehicles	130	140	160	170	180	180	190	200	210	230	250	280	270	280
Total- Diesel	130	140	160	170	180	180	190	200	210	230	260	300	290	310
Highway Vehicle Total	900	950	1,020	1,060	1,040	1,050	1,080	1,090	1,100	1,070	1,050	1,070	1,050	1,060
Aircraft	100	90	90	70	80	80	70	70	70	70	70	70	70	80
Railroads	60	60	60	60	60	50	50	50	50	60	50	50	50	40
Vessels	40	30	30	30	30	30	20	30	30	30	30	30	30	20
Farm Machinery	40	40	50	40	50	50	60	60	70	70	60	60	60	60
Construction Machinery	10	10	20	20	10	10	20	20	20	20	20	20	20	20
Industrial Machinery	20	20	20	20	20	20	20	30	30	30	20	20	20	20
Other Off-highway Vehicles	4	4	4	5	4	5	5	5	5	5	5	5	5	5
Transportation Total	1,170	1,200	1,290	1,300	1,290	1,290	1,320	1,350	1,370	1,350	1,300	1,320	1,300	1,300

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 14

SULFUR OXIDE EMISSIONS FROM TRANSPORTATION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Highway Vehicles														
Gasoline-powered														
Passenger cars	120	120	130	130	130	130	140	150	150	150	140	140	150	160
Light trucks - 1	20	20	20	30	30	30	30	30	30	30	30	30	30	30
Light trucks - 2	6	6	7	8	8	9	10	10	20	20	20	20	20	20
Heavy duty vehicles	10	10	20	10	10	10	10	10	10	10	10	10	10	10
Motorcycles	0	0	0	0	0	0	1	1	1	1	1	0	0	0
Total - Gasoline	160	160	180	180	180	180	190	200	210	210	200	200	210	220
Diesel-powered														
Passenger cars	0	0	0	0	0	0	0	1	1	3	5	10	10	10
Light trucks	0	0	0	0	0	0	0	0	0	1	2	3	3	4
Heavy duty vehicles	100	110	130	140	140	140	150	160	170	180	200	220	210	220
Total - Diesel	100	110	130	140	140	140	150	160	170	180	210	230	220	230
Highway Vehicle Total	260	280	300	320	320	320	350	360	380	390	420	450	440	450
Aircraft	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Railroads	130	110	120	120	120	110	120	120	110	120	120	110	110	100
Vessels	150	130	120	140	140	140	160	180	210	250	270	250	200	180
Farm Machinery	30	30	30	30	30	30	40	40	40	50	40	40	40	40
Construction Machinery	10	10	20	20	20	20	20	20	20	20	20	20	20	20
Industrial Machinery	20	20	20	20	20	20	20	30	30	20	20	20	10	10
Other Off-Highway Vehicles	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Transportation Total	610	590	620	660	660	650	720	760	800	860	900	900	830	810

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to to independent rounding.

TABLE 15

NITROGEN OXIDE EMISSIONS FROM TRANSPORTATION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Highway Vehicles														
Gasoline-powered														
Passenger cars	3,890	4,190	4,510	4,710	4,370	4,370	4,410	4,410	4,360	3,960	3,660	3,490	3,470	3,380
Light trucks - 1	490	550	630	650	610	600	640	660	650	640	640	690	640	660
Light trucks - 2	210	220	270	300	300	310	380	450	510	530	520	570	510	510
Heavy duty vehicles	440	430	480	470	460	430	440	420	410	380	360	350	300	290
Motorcycles	3	4	5	6	7	7	6	7	7	10	10	10	10	10
Total- Gasoline	5,030	5,390	5,890	6,140	5,750	5,720	5,880	5,950	5,940	5,520	5,190	5,110	4,930	4,850
Diesel-powered														
Passenger cars	0	0	0	0	0	1	1	2	3	8	10	20	30	30
Light trucks	0	0	0	0	0	0	0	0	1	2	6	10	10	10
Heavy duty vehicles	950	1,050	1,220	1,340	1,390	1,410	1,520	1,620	1,710	1,840	2,020	2,230	2,080	2,090
Total - Diesel	950	1,050	1,220	1,340	1,390	1,410	1,520	1,620	1,710	1,850	2,040	2,260	2,120	2,130
Highway Vehicle Total	5,990	6,440	7,110	7,480	7,140	7,120	7,410	7,570	7,650	7,380	7,230	7,370	7,040	6,980
Aircraft	110	110	100	100	100	100	100	100	110	120	110	110	110	110
Railroads	640	620	690	730	730	660	690	700	710	750	750	710	660	650
Vessels	90	100	100	120	110	120	130	150	170	180	150	190	160	150
Farm Machinery	400	410	430	410	440	430	490	510	540	560	460	480	470	440
Construction Machinery	180	190	200	220	190	190	210	250	260	230	230	200	200	200
Industrial Machinery	220	230	240	240	250	240	250	260	260	260	260	240	220	220
Other Off-highway Vehicles	10	9	10	10	10	10	10	10	10	10	10	10	10	10
Transportation Total	7,640	8,120	[illegible]	9,310	8,970	8,890	9,290	9,550	9,710	9,490	9,200	9,310	8,870	8,760

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 16

VOC EMISSIONS FROM TRANSPORTATION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Highway Vehicles														
Gasoline-powered														
Passenger cars	8,530	8,340	8,040	7,560	6,760	6,320	6,400	6,020	5,770	5,010	4,440	4,080	3,940	3,860
Light trucks - 1	1,130	1,120	1,220	1,140	1,040	990	1,060	1,030	970	900	870	910	800	800
Light trucks - 2	450	430	500	520	500	520	650	730	830	860	790	840	720	680
Heavy duty vehicles	830	740	800	730	640	610	640	580	570	540	530	530	440	420
Motorcycles	80	120	140	160	170	180	180	180	180	150	110	80	60	60
Total- Gasoline	11,020	10,750	10,700	10,110	9,110	8,820	8,930	8,540	8,320	7,460	6,740	6,440	5,960	5,820
Diesel-powered														
Passenger cars	0	0	0	0	0	0	0	0	1	2	3	4	4	5
Light trucks	0	0	0	0	0	0	0	0	0	1	2	3	3	3
Heavy duty vehicles	100	110	120	130	130	130	150	160	170	180	200	220	210	220
Total - Diesel	100	110	120	130	130	130	150	160	170	180	200	220	220	230
Highway Vehicle Total	11,120	10,860	10,820	10,230	9,240	8,950	9,080	8,700	8,490	7,640	6,930	6,660	6,180	6,040
Aircraft	250	230	210	190	190	190	170	170	180	180	180	160	160	170
Railroads	160	150	170	180	180	160	170	170	170	180	180	170	160	160
Vessels	330	350	380	390	380	400	410	420	430	420	400	430	410	410
Farm Machinery	250	240	240	240	230	220	230	220	220	220	190	180	180	160
Construction Machinery	40	40	40	40	40	30	40	40	40	40	40	40	30	30
Industrial Machinery	120	120	130	120	90	80	90	90	90	80	80	100	90	80
Other Off-highway Vehicles	110	130	140	150	140	160	160	160	160	160	160	160	160	160
Transportation Total	12,380	12,120	12,130	11,540	10,490	10,190	10,350	9,970	9,780	8,920	8,160	7,900	7,370	7,210

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 17

CARBON MONOXIDE EMISSIONS FROM TRANSPORTATION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Highway Vehicles														
Gasoline-powered														
Passenger cars	47,610	46,990	45,990	43,870	40,170	39,390	39,660	36,920	35,790	32,000	29,200	27,280	26,360	26,520
Light trucks - 1	5,650	5,760	6,230	5,900	5,650	5,490	6,180	6,010	5,860	5,690	5,480	5,920	5,240	5,310
Light trucks - 2	2,020	1,920	2,200	2,300	2,250	2,390	3,100	3,470	4,030	4,230	4,000	4,400	3,860	3,850
Heavy duty vehicles	6,880	6,390	7,060	6,750	6,140	5,990	6,470	6,000	6,060	5,800	5,690	5,730	4,820	4,700
Motorcycles	240	360	400	450	510	510	520	510	520	430	310	230	160	160
Total - Gasoline	62,400	61,420	61,880	59,270	54,720	53,770	55,930	52,910	52,260	48,150	44,680	43,560	40,440	40,540
Diesel-powered														
Passenger cars	0	0	0	0	0	0	1	1	2	4	7	10	10	20
Light trucks	0	0	0	0	0	0	0	0	1	2	3	6	6	7
Heavy duty vehicles	290	320	370	400	390	390	440	470	500	530	590	680	630	660
Total - Diesel	290	320	370	400	390	390	440	470	500	530	600	690	650	690
Highway Vehicle Total	62,690	61,750	62,250	59,680	55,110	54,170	56,370	53,390	52,770	48,670	45,290	44,250	41,090	41,230
Aircraft	900	890	860	840	860	880	860	900	960	990	990	960	950	980
Railroads	250	240	260	270	270	240	250	260	260	270	270	250	240	230
Vessels	1,150	1,220	1,230	1,350	1,300	1,360	1,400	1,420	1,470	1,420	1,380	1,440	1,390	1,400
Farm Machinery	3,570	3,450	3,140	3,250	3,000	2,930	2,780	2,600	2,370	2,240	2,040	1,880	1,780	1,460
Construction Machinery	580	510	470	450	430	370	410	360	340	370	460	370	320	260
Industrial Machinery	1,780	1,710	1,810	1,580	1,230	1,060	1,070	1,100	1,070	820	1,110	1,330	1,190	1,030
Other Off-highway Vehicles	840	870	910	950	960	990	1,000	1,020	1,050	1,080	1,090	1,100	1,110	1,120
Transportation Total	71,760	70,640	70,930	68,370	63,160	62,000	64,140	61,050	60,290	55,860	52,630	51,580	48,070	47,710

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 1R

PARTICULATE EMISSIONS FROM FUEL COMBUSTION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Coal														
Electric utilities	2,220	1,960	1,750	1,690	1,560	1,420	1,150	1,060	1,050	860	720	640	490	480
Industrial	1,300	920	650	550	440	360	250	230	220	250	250	280	220	210
Residential/Commercial	120	110	80	80	70	60	50	50	50	50	50	50	50	60
Coal Total	3,640	2,990	2,480	2,320	2,070	1,840	1,450	1,340	1,320	1,160	1,020	970	760	750
Fuel Oil														
Electric utilities	110	120	120	130	130	120	170	140	140	120	110	90	70	60
Industrial	80	80	80	90	80	70	80	90	80	70	60	50	50	30
Residential/Commercial	80	70	70	70	60	60	60	60	60	50	50	40	40	30
Fuel Oil Total	270	270	270	290	270	250	260	290	280	240	220	180	160	120
Natural Gas														
Electric utilities	6	6	6	6	5	5	5	5	5	5	6	6	5	4
Industrial	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Residential/Commercial	10	10	10	10	10	10	10	10	10	10	10	10	10	9
Natural Gas Total	36	36	36	36	35	35	35	35	35	35	36	36	35	33
[redacted]														
Industrial	140	130	140	140	130	90	90	100	100	100	100	90	80	90
Residential	380	360	360	330	350	400	450	510	590	700	800	830	890	940
Wood Total	520	490	500	470	480	490	540	610	690	800	900	920	970	1,030
Other Fuels														
Industrial	40	40	40	40	30	40	40	30	30	30	30	20	20	20
Residential	4	4	4	4	3	3	3	3	3	3	2	2	2	2
Other Fuels Total	44	44	44	44	33	43	43	33	33	33	32	22	22	22
Fuel Combustion Total	4,510	3,830	3,330	3,160	2,890	2,660	2,330	2,310	2,360	2,270	2,210	2,130	1,950	1,950

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 19

SULFUR OXIDE EMISSIONS FROM FUEL COMBUSTION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Coal														
Electric utilities	14,330	14,080	14,410	15,600	15,100	15,200	15,650	15,580	14,080	14,550	14,190	13,580	13,270	13,250
Industrial	2,840	2,300	2,180	1,970	1,800	1,700	1,490	1,450	1,500	1,610	1,380	1,560	1,500	1,540
Residential/Commercial	340	320	230	220	240	210	200	200	230	190	140	170	210	220
Coal Total	17,510	16,700	16,820	17,790	17,140	17,110	17,340	17,230	15,810	16,350	15,710	15,310	14,980	15,010
Fuel Oil														
Electric utilities	1,460	1,460	1,390	1,570	1,520	1,380	1,440	1,630	1,660	1,650	1,310	1,130	950	770
Industrial	1,140	1,070	1,170	1,180	1,110	880	1,090	1,210	1,100	910	850	680	700	440
Residential/Commercial	1,000	950	990	930	860	760	870	850	780	640	720	560	550	400
Fuel Oil Total	3,600	3,480	3,550	3,680	3,490	3,020	3,400	3,690	3,560	3,000	2,880	2,370	2,200	1,610
Natural Gas														
Electric utilities	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Industrial	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Residential/Commercial	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Natural Gas Total	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Wood														
Industrial	3	3	3	3	3	3	4	4	4	4	4	4	4	4
Residential	5	4	4	4	4	5	6	6	7	8	10	10	10	10
Wood Total	8	7	7	7	7	8	10	10	11	12	14	14	14	14
Other Fuels														
Industrial	160	140	140	130	160	100	140	110	130	130	120	100	80	80
Residential	20	20	10	10	10	10	10	10	9	9	6	6	5	5
Other Fuels Total	180	160	150	140	170	110	150	120	139	139	126	106	85	85
Fuel Combustion Total	21,300	20,350	20,530	21,620	20,810	20,250	20,900	21,060	19,520	19,510	18,740	17,800	17,280	16,720

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 20

NITROGEN OXIDE EMISSIONS FROM FUEL COMBUSTION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Coal														
Electric utilities	3,170	3,230	3,410	3,740	3,780	3,880	4,270	4,550	4,470	4,820	5,150	5,250	5,200	5,410
Industrial	700	580	560	510	480	470	440	420	420	460	400	460	450	460
Residential/Commercial	40	40	40	40	40	40	30	40	30	30	30	30	30	30
Coal Total	3,910	3,850	4,010	4,290	4,300	4,390	4,740	5,010	4,930	5,310	5,580	5,740	5,680	5,900
Fuel Oil														
Electric utilities	390	480	600	700	670	600	620	730	680	570	440	380	270	260
Industrial	300	310	320	340	310	270	340	360	350	260	220	190	200	150
Residential/Commercial	300	300	300	300	280	260	290	280	280	230	220	180	170	140
Fuel Oil Total	990	1,090	1,220	1,340	1,260	1,130	1,250	1,370	1,310	1,060	880	750	640	550
Natural Gas														
Electric utilities	940	960	960	870	830	740	710	730	720	790	830	820	730	620
Industrial	2,770	2,830	2,900	2,930	2,820	2,570	2,800	2,810	2,790	2,710	2,240	2,140	2,230	2,020
Residential/Commercial	330	340	350	340	330	340	350	330	340	350	330	320	330	300
Natural Gas Total	4,040	4,130	4,210	4,140	3,980	3,650	3,860	3,870	3,850	3,850	3,400	3,280	3,290	2,940
Wood														
Industrial	70	70	70	70	70	70	80	80	90	90	90	90	80	90
Residential	30	30	30	30	30	30	40	40	50	60	60	70	70	70
Wood Total	100	100	100	100	100	100	120	120	140	150	150	160	150	160
Other Fuels														
Industrial	50	50	50	50	50	50	60	50	60	70	70	60	60	60
Residential	60	50	60	50	50	40	50	40	40	30	30	30	20	20
Other Fuels Total	110	100	110	100	100	90	110	90	100	100	100	90	80	80
Fuel Combustion Total	9,150	9,270	9,650	9,970	9,740	9,360	10,080	10,460	10,330	10,470	10,110	10,020	9,840	9,630

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 21

VOC EMISSIONS FROM FUEL COMBUSTION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Coal														
Electric utilities	20	20	20	20	20	20	20	20	20	30	30	30	30	30
Industrial	4	3	3	3	3	3	3	2	2	3	2	3	3	3
Residential/Commercial	60	50	30	30	20	20	20	10	10	10	10	10	10	10
Coal Total	84	73	53	53	43	43	43	32	32	43	42	43	43	43
Fuel Oil														
Electric utilities	7	9	10	10	10	10	10	20	20	10	8	6	5	4
Industrial	4	5	5	5	5	5	5	6	6	4	3	3	3	3
Residential/Commercial	8	8	8	8	7	7	8	7	7	6	6	5	4	4
Fuel Oil Total	19	22	23	23	22	22	23	33	31	20	17	14	12	11
Natural Gas														
Electric utilities	5	5	5	5	5	4	4	4	4	5	5	5	4	4
Industrial	70	70	70	70	70	60	70	70	70	70	50	50	50	50
Residential/Commercial	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Natural Gas Total	95	95	95	95	95	84	94	94	94	95	75	75	74	74
Wood														
Industrial	40	40	40	40	40	40	50	50	50	50	50	50	50	50
Residential	700	660	660	620	640	740	840	940	1,130	1,380	1,600	1,730	1,870	2,000
Wood Total	740	700	700	660	680	780	890	990	1,180	1,430	1,650	1,780	1,920	2,050
Other Fuels														
Industrial	7	7	8	7	7	10	10	9	10	10	10	9	7	8
Residential	2	2	2	2	2	2	2	2	2	1	1	1	1	1
Other Fuels Total	9	9	10	9	9	12	12	11	12	11	11	10	8	9
Fuel Combustion Total	950	900	880	840	850	940	1,060	1,160	1,350	1,600	1,800	1,920	2,060	2,190

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 22

CARBON MONOXIDE EMISSIONS FROM FUEL COMBUSTION
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Coal														
Electric utilities	100	100	100	120	120	120	130	140	140	160	170	180	190	190
Industrial	90	80	70	70	60	60	60	50	60	60	50	60	60	60
Residential/Commercial	510	450	280	230	220	170	150	100	130	120	100	110	120	130
Coal Total	700	630	450	420	400	350	340	330	330	340	320	350	360	380
Fuel Oil														
Electric utilities	40	50	60	70	70	60	70	80	80	60	40	40	30	30
Industrial	40	40	50	50	40	40	50	50	50	30	30	30	30	20
Residential/Commercial	50	50	60	50	50	50	50	50	50	50	40	30	30	30
Fuel Oil Total	130	140	170	170	160	150	170	180	180	140	110	100	90	80
Natural Gas														
Electric utilities	80	90	90	80	70	70	70	70	70	80	80	80	70	60
Industrial	420	430	440	440	430	390	420	420	420	410	350	330	340	310
Residential/Commercial	70	70	70	70	70	70	70	70	70	70	70	60	70	70
Natural Gas Total	570	590	600	590	570	530	560	560	560	560	500	470	480	440
Wood														
Industrial	110	110	120	120	120	110	130	130	190	190	190	190	140	150
Residential	2,310	2,200	2,190	2,040	2,140	2,450	2,780	3,120	3,640	4,340	5,070	5,130	5,500	5,810
Wood Total	2,420	2,310	2,310	2,160	2,260	2,560	2,910	3,250	3,790	4,490	5,160	5,280	5,640	5,960
Other Fuels														
Industrial	10	10	20	10	10	20	20	20	20	20	20	20	20	20
Residential	10	10	10	10	10	10	11	10	10	8	6	6	5	5
Other Fuels Total	20	20	30	20	20	30	31	30	30	28	26	26	25	25
Fuel Combustion Total	3,840	3,690	3,560	3,360	3,410	3,620	4,010	4,350	4,890	5,560	6,120	6,230	6,600	6,880

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from summary table value due to independent rounding.

TABLE 23

PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESSES
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Cattle Feed lots (0211)	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Cotton Ginning (0724)	20	20	30	20	20	30	20	30	20	20	20	30	20	10
Metallic Ore Mining (10)	530	490	480	480	400	320	260	180	210	210	180	200	110	110
Coal Mining (1211)	350	300	300	280	250	250	260	260	250	280	290	290	290	280
Crushed Stone (142)	1,350	1,260	1,210	1,180	980	760	660	560	610	570	450	300	140	140
Sand and Gravel (144)	50	50	50	50	50	40	40	50	50	50	40	40	30	30
Clays (145)	1,610	1,350	1,140	950	560	290	220	210	210	150	130	70	60	70
Potash/Phosphate Rock (1474,1475)	40	40	40	40	40	30	30	30	30	30	30	10	10	10
Feed and Grain Milling (204)	80	80	80	70	60	60	50	50	50	50	50	50	60	60
Lumber and Plywood (24)	80	80	90	90	80	70	60	90	90	80	70	70	60	70
Pulp Mills (261,262)	570	480	440	310	270	180	150	150	110	110	110	80	90	90
Chemicals (28)	220	150	170	150	130	100	100	110	110	110	100	90	70	80
Petroleum Refining (2911)	60	70	70	70	70	70	60	60	60	50	50	40	40	30
Asphalt Paving and Roofing (295)	560	560	550	590	500	320	220	130	120	130	110	90	90	90
Glass (321,322)	60	50	50	50	40	40	40	40	30	30	30	30	30	30
Cement (3241)	1,380	1,350	1,190	870	690	560	540	550	560	480	350	280	210	230
Brick and Tile (3251)	40	50	50	50	40	30	40	40	40	40	30	20	20	20
Concrete, Lime, Gypsum (327)	520	430	390	370	320	240	210	150	140	130	120	100	80	80
Clay Sintering (3295)	100	100	100	90	70	60	30	20	10	10	10	10	10	10
Iron and Steel (3312)	1,190	970	970	890	760	570	500	440	450	400	310	300	200	210
Ferroalloys (3313)	180	160	150	160	150	90	80	70	60	40	30	30	10	10
Iron and Steel Foundries (332)	170	170	160	130	120	80	80	70	70	60	50	40	40	40
Primary Nonferrous Smelters (333)	320	300	290	250	200	170	140	100	100	100	90	80	60	60
Secondary Nonferrous Smelters (334,336)	50	60	50	50	50	50	50	40	40	50	40	40	30	30
Grain Elevators (4821,5153)	670	790	730	720	530	590	550	500	500	550	440	440	450	270
TOTAL	10,110	9,350	8,770	7,910	6,440	5,030	4,470	3,950	3,960	3,760	3,170	2,830	2,620	2,310

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 24

SULFUR OXIDE EMISSIONS FROM INDUSTRIAL PROCESSES
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Natural Gas Production (1311)	100	100	120	150	160	160	130	170	130	140	140	150	140	160
Pulp Mills (261,262)	110	100	110	110	110	100	110	100	100	100	110	110	100	110
Sulfuric Acid (2819)	540	530	570	570	440	330	250	260	260	250	250	220	170	180
Carbon Black (2895)	0	0	10	10	10	10	10	10	10	10	10	10	10	10
Petroleum Refining (2911)	700	750	790	850	850	830	850	890	900	880	840	770	760	740
Glass (321,322)	20	20	20	30	30	30	30	30	30	30	30	30	30	30
Cement (3241)	560	550	560	560	540	460	510	580	630	630	570	550	480	520
Lime (3274)	30	30	30	30	30	30	30	30	30	30	30	30	20	20
Iron and Steel (3312)	680	590	660	510	460	480	450	450	430	460	390	370	260	270
Primary Copper (3331)	3,180	2,840	3,130	3,210	2,710	2,160	2,040	1,770	1,370	1,450	990	1,270	970	880
Primary Lead and Zinc (3332,3333)	410	360	310	190	160	110	110	90	100	120	70	70	160	140
Primary Aluminum (3334)	70	70	70	80	80	60	70	80	80	80	90	80	60	60
Secondary Lead (3341)	20	20	20	20	20	20	30	30	30	40	30	30	30	20
TOTAL	6,210	5,750	6,170	6,120	5,610	4,740	4,610	4,610	4,100	4,210	3,580	3,690	3,150	3,090

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 29

NITROGEN OXIDE EMISSIONS FROM INDUSTRIAL PROCESSES
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Pulp Mills (261,262)	20	20	30	30	30	20	30	30	30	30	30	30	30	30
Organic Chemicals (286)	60	70	60	80	70	50	60	50	60	70	50	50	40	50
Ammonia (2873)	30	40	40	40	40	40	40	40	40	50	50	50	40	30
Nitric Acid (2873)	150	140	140	140	130	110	110	110	100	100	100	90	60	50
Petroleum Refining (2911)	220	230	230	240	240	240	240	260	260	250	240	210	200	200
Glass (321,322)	40	40	50	50	50	50	50	60	60	60	50	60	50	50
Cement (3241)	90	90	100	100	100	80	90	90	100	100	90	80	70	80
Lime (3274)	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Iron and Steel (3312)	70	70	70	80	80	70	70	70	80	70	60	60	40	40
TOTAL	710	720	730	770	750	690	710	740	750	740	690	650	560	560

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 26

VOLATILE ORGANIC COMPOUND EMISSIONS FROM INDUSTRIAL PROCESSES
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Crude oil production, storage and transfer (1311,4463)	550	560	560	560	540	530	530	550	570	570	560	540	530	530
Food and beverages (20)	190	190	190	180	180	170	170	170	180	180	170	180	180	180
Textiles (22)	10	10	10	10	20	20	20	20	20	20	20	20	20	10
Graphic arts (27)	290	270	310	320	300	250	280	290	350	350	340	260	240	280
Plastics (2821,3079)	380	360	410	430	410	350	390	410	470	490	460	390	350	420
Organic chemicals (286)	570	600	680	740	770	690	810	820	820	810	710	650	490	570
Other chemicals (28)	590	530	530	550	520	460	510	560	560	580	530	540	470	500
Petroleum refining (2911)	720	760	790	820	850	880	890	940	970	970	970	960	900	810
Rubber tires (3011)	50	50	60	60	50	50	50	60	60	50	40	50	40	50
Iron and steel (3312)	110	80	100	110	100	90	100	90	90	90	80	70	50	40
Petroleum product storage and transfer (5171,5541)	1,570	1,640	1,720	1,780	1,730	1,740	1,780	1,780	1,810	1,660	1,490	1,440	1,370	1,370
Dry cleaning (721)	240	230	240	240	240	230	250	260	290	290	290	240	210	210
Adhesives[1]	50	40	50	50	50	40	40	50	60	60	50	40	40	40
Degreasing[1]	640	560	590	600	540	450	490	490	550	560	510	420	360	410
Solvent extraction processes[1]	40	40	40	40	40	30	30	40	50	40	40	40	30	40
Surface coating[1]	2,390	2,230	2,550	2,570	2,340	1,880	2,090	2,190	2,510	2,500	2,320	1,820	1,560	1,780
Other organic solvent use[1]	270	240	270	290	280	220	250	290	280	300	290	300	250	260
TOTAL	8,670	8,410	9,100	9,360	8,960	8,090	8,690	9,020	9,620	9,500	8,870	7,980	7,100	7,490

[1]This is a general category which includes process emissions from organic solvent use in a wide variety of industries. Thus no specific SIC is given.

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 27

CARBON MONOXIDE EMISSIONS FROM INDUSTRIAL PROCESSES
(GIGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Pulp Mills (261,262)	550	550	590	610	610	550	620	630	650	660	720	720	700	760
Inorganic Pigments (2816)	20	20	20	20	30	20	30	30	30	30	30	30	30	30
Charcoal (2861)	50	50	50	50	40	30	30	40	40	50	40	40	30	30
Organic Chemicals (286)	310	320	380	400	410	410	410	450	490	510	450	470	420	470
Ammonia (2873)	100	110	110	110	110	120	120	130	120	130	140	140	110	100
Carbon Black (2895)	2,600	2,380	1,780	1,890	1,680	1,420	1,550	1,760	1,630	1,590	1,290	1,320	950	1,030
Petroleum Refining (2911)	2,000	2,070	2,100	2,140	2,060	2,040	1,960	1,870	1,780	1,690	1,600	1,110	690	630
Asphalt Roofing (2952)	10	10	10	10	10	10	10	20	20	20	10	10	10	10
Lime (3274)	10	10	20	20	20	10	20	20	20	20	10	10	10	10
Iron and Steel (3312)	1,620	1,470	1,560	1,580	1,460	1,100	1,180	1,160	1,210	1,200	910	990	640	660
Iron Foundries (3321)	1,090	1,160	1,180	1,060	920	590	590	470	440	410	310	290	280	280
Primary Aluminum (3334)	590	580	610	670	730	580	630	680	720	750	760	740	540	550
TOTAL	8,950	8,730	8,410	8,550	8,080	6,870	7,150	7,230	7,140	7,060	6,340	5,870	4,420	4,580

NOTE: One gigagram equals 10^9 grams or 10^3 metric tons (1.1×10^3 short tons). Total may differ slightly from sum of source category totals due to independent rounding of data.

TABLE 28

LEAD EMISSIONS FROM INDUSTRIAL PROCESSES
(MEGAGRAMS/YEAR)

Source Category	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Iron & Steel Industry	3,087	2,441	2,352	2,326	1,772	1,073	913	873	911	769	476	468	335	369
Primary Nonferrous Metals	12,350	11,960	8,414	7,118	6,416	5,569	3,465	1,519	1,463	1,316	1,038	859	874	872
Secondary Nonferrous Metals	5,612	5,484	4,650	3,286	2,890	1,905	1,682	1,510	1,440	1,391	1,020	883	784	724
Mineral Products	784	716	630	464	422	440	400	374	378	296	272	254	202	171
Miscellaneous	2,050	1,879	2,221	2,446	1,793	1,338	1,599	1,411	1,227	1,389	778	585	515	389
Total Industrial	23,883	22,480	18,567	15,640	13,293	10,325	8,059	5,687	5,419	5,161	3,584	3,049	2,710	2,525

NOTE: One megagram equals 10^6 grams or one metric ton (1.1 short ton).

3. METHODS

The generation of an emission inventory involves many steps to achieve the desired result, which is to estimate the amount of emissions for selected pollutants in a defined geographical area. Ideally, nationwide emission estimates should result from a summation of county, State, and regional data in which each component is reported separately. The National Emissions Data System (NEDS) uses this procedure. The methods used to prepare data for this publication are as similar as possible to those used for NEDS data preparation. Since NEDS uses a more detailed procedure involving calculation of emissions for individual sources and summation of these individual emission totals to produce national totals, there is a much greater chance for errors or omissions to occur in the NEDS data. Because of the basic similarity of techniques, discrepancies between national totals reported herein and those given in NEDS reports are due largely to incomplete data reporting and errors in the NEDS data. The quality of NEDS data over time has improved so that the differences between NEDS emission reports for 1977 and later years and national emission totals determined by the procedure used for this publication are not as great as in earlier NEDS reports. Moreover, historical NEDS data are not revised to account for updated emission factors, errors or omissions in the data. As a result annual NEDS publications do not necessarily represent a consistent trend in estimated emissions.

Because it is impossible to test every pollutant source individually, particularly area sources, an estimating procedure must be used. In order to do this, however, one must either estimate the emissions directly or estimate the magnitude of other variables that can then be related to emissions. These indicators include fuel consumption, vehicle miles, population, sales, tons of refuse burned, raw materials processed, etc., which are then multiplied by appropriate emission factors to obtain emission estimates.

The limitations and applicability of emission factors must be understood. In general, emission factors are not precise indicators of emissions from a single source; rather, they are quantitative estimates of the average rate of pollutant released as a result of some activity. They are most valid when applied to a large number of sources and processes. If their limitations are recognized, emission factors are extremely useful in determining emission levels. A detailed discussion of emission factors and related information is contained in Reference 2. The emission factor thus relates quantity of pollutants emitted to indicators such as those noted above, and is a practical approach for determining estimates of emissions from various source categories.

A basic discussion of trends is meaningful only when there is a common basis for evaluation. It was necessary, therefore, to quantify emissions using the same criteria for each year. This meant using the

same estimation techniques, using equal or equivalent data sources, covering the same pollutant sources, and using compatible estimates of pollutant control levels from year to year. Estimates for previous years were updated using current emission factors and including the most recent information available. The criteria used in calculating emissions was the same for all years.

The methodology used in generation of emission estimates for individual source categories follows.

3.1 Transportation

3.1.1 Motor Vehicles

Emission estimates from gasoline-and diesel-powered motor vehicles were based upon vehicle-mile tabulations and emission factors. Eight vehicle categories are considered; light duty gasoline (mostly passenger cars), light duty diesel passenger cars, light duty gasoline trucks (trucks less than 6000 pounds in weight), light duty gasoline trucks 6000 to 8500 pounds in weight, light duty diesel trucks, heavy duty gasoline trucks and buses, and heavy duty diesel trucks and buses, and motorcycles. The emission factors used are based on the latest available data from Reference 3. The MOBILE3 model, developed by the EPA Office of Mobile Sources was used to calculate emission factors for each year. The current MOBILE3 model does not provide emission factors for California. The earlier model, MOBILE2, was used for California. The use of MOBILE2 for California may cause VOC emissions from highway vehicles to be slightly underestimated, but should have a negligible effect on CO and NO_x emissions. The emission factors are weighted to consider the approximate amount of motor vehicle travel in low altitude areas, high altitude areas, and California to obtain overall national average emission factors. For each area a representative average annual temperature, together with national averages for motor vehicle model year distributions and hot/cold start vehicle operation percentages were used to calculate the emission factors. Average speed is taken into account according to the published distribution of vehicle-miles travelled (VMT) as published in Reference 4. The published VMT are divided into three road categories corresponding to roads with assumed average speeds of 55 miles per hour for interstates and other primary highways, 45 miles per hour for other rural roads, and 19.6 miles per hour for other urban streets. For 1940 and 1950, average speeds were assumed to be 45, 35 and 19.6 miles per hour for these roadway classifications.

Lead emission estimates from gasoline-powered-motor vehicles, were based on highway gasoline consumption, lead content of gasoline, percent unleaded gasoline, and emission factors. The gasoline consumption is based on highway gasoline usage as published in Reference 4. The lead content of gasoline was obtained from Reference 13 for 1970-74 and Reference 31 for 1975-83. The percent unleaded gasoline is obtained from Reference 6. The emission factor was also obtained from Reference 31.

3.1.2 Aircraft

Aircraft emissions are based on emission factors and aircraft activity statistics reported by the Federal Aviation Administration.[5] Emissions are based on the number of landing-takeoff (LTO) cycles. Any emissions in cruise mode, which is defined to be above 3000 feet (1000 meters) are ignored. Average emission factors for each year, which take into account the national mix of aircraft types for general aviation, military, and commercial aircraft, are used to compute the emissions.

3.1.3 Railroads

The Department of Energy reports consumption of diesel fuel and residual fuel oil by railroads.[6] Average emission factors applicable to diesel fuel consumption were used to calculate emissions. The average sulfur content of each fuel was used to estimate SO_x emissions. Coal consumption by railroads was obtained from References 7 and 13.

3.1.4 Vessels

Vessel use of diesel fuel, residual oil, and coal is reported by the Department of Energy.[6,7] Gasoline use is based on national boat and motor registrations, coupled with a use factor (gallons/motor/year) from Reference 8 and marine gasoline sales as reported in Reference 4. Emission factors from AP-42[2] are used to compute emissions. Since AP-42 does not contain an emission factor for coal use by vessels, an average emission factor for coal combustion in boilers was used.

3.1.5 Nonhighway Use of Motor Fuels

Gasoline and diesel fuel are consumed by off-highway vehicles. The fuel use is divided into seven categories; farm tractors, other farm machinery, construction equipment, industrial machinery, small general utility engines such as lawnmowers and snowthrowers, snowmobiles, and motorcycles. Fuel use is estimated for each category from estimated equipment population and an annual use factor of gallons per unit per year[8], together with reported off-highway diesel fuel deliveries given in Reference 6 and off-highway gasoline sales reported in Reference 4.

3.2 Fuel Combustion in Stationary Sources

3.2.1 Coal

Bituminous coal, lignite, and anthracite coal use are reported by the Department of Energy.[7,11] Most coal is consumed by electric utilities. Average emission factors and the sulfur content of each type of coal were used to estimate emissions. Degree of particulate

control was based on a report by Midwest Research Institute[9] together with data from NEDS[10]. Sulfur content data for electric utilities are available from the Department of Energy[11]. Sulfur contents for other categories are based on coal shipments data reported in Reference 7 and average sulfur contents of coal shipped from each production district as reported in Reference 13 or 24. For electric utilities, SO_2 emissions are adjusted to account for flue gas desulfurization controls, based on data reported in Reference 25.

3.2.2 Fuel Oil

Distillate oil, residual oil, and kerosene are consumed by stationary sources nationwide. Consumption by user category is reported by the Department of Energy.[6] Average emission factors and the sulfur content of each fuel were used to estimate emissions.

3.2.3 Natural Gas

Natural gas consumption data are also reported by the Department of Energy.[12] Average emission factors from AP-42[2] were used to calculate the emission estimates.

3.2.4 Other Fuels

Consumption of wood has been estimated by the Department of Energy.[27] Consumption of bagasse is based on data reported in NEDS.[10] Sales of liquefied petroleum gas (LPG) are reported in Reference.[6] Estimated consumption of coke and coke-oven gas are based on Reference 13 and 26, together with data from NEDS. Average emission factors were used to calculate emissions.

Lead emissions from the combustion of waste oil were based on information obtained from Reference 32. The amount of waste oil burned has been assumed to remain constant and the emissions have been changed as a result of a decrease in the lead content of the waste oil.

3.3 Industrial Processes

In addition to fuel combustion, certain other industrial processes generate and emit varying quantities of pollutants into the air. The lack of published national data on production, type of equipment, and controls, as well as an absence of emission factors, makes it impossible to include estimates of emissions from all industrial process sources.

Production data for industries that produce the great majority of emissions were derived from literature data. Generally, the Minerals Yearbook,[13] published by the Bureau of Mines, and Current Industrial Reports,[14] published by the Bureau of the Census, provide adequate data for most industries. Average emission factors were applied to

production data to obtain emissions. Control efficiencies applicable to various processes were estimated on the basis of published reports[9] and from NEDS data.[10]

For the purposes of this report, petroleum product storage and marketing operations (gasoline, crude oil, and distillate fuel oil storage and transfer, gasoline bulk terminals and bulk plants, retail gasoline service stations) are included as industrial processes. Also included as industrial processes are industrial surface coating and degreasing operations, graphic arts (printing and publishing), and dry cleaning operations. All of these processes involve the use of organic solvents. Emissions from the consumption of organic solvents are estimated based on data reported in Reference 15. It is assumed that all solvents consumed are eventually released as air pollution, except for industrial surface coating operations. Estimates of the level of control for surface coating operations have been derived from References 10 and 28. In addition, the methodology given in Reference 15 has been updated to be consistent with similar procedures used for estimating organic solvent emissions in the National Emissions Data System (NEDS).[29]

3.3.1 Miscellaneous Industrial Processes for Lead

Lead emissions from miscellaneous industrial processes include the major source of lead alkyl production as well as other minor sources such as type metal production, can soldering, cable covering, and other minor sources. The lead alkyl production is based on information from Reference 33. The production information for the other minor sources is from Reference 13.

3.4 Solid Waste Disposal

A study conducted in 1968 on solid waste collection and disposal practices[16] was the basis for estimating emissions from solid waste disposal. Results of this study indicate that the average collection rate of solid waste is about 5.5 pounds per capita per day in the United States. It has been stated that a conservative estimate of the total generation rate is 10 pounds per capita per day. The results of this survey were updated based on data reported in NEDS and used to estimate, by disposal method, the quantities of solid waste generated. Average emission factors were applied to these totals to obtain estimates of total emissions from the disposal of solid wastes.

3.5 Miscellaneous Sources

3.5.1 Forest Fires

The Forest Service of the Department of Agriculture publishes information on the number of forest fires and the acreage burned.[17] Estimates of the amount of material burned per acre are made to estimate

the total amount of material burned. Similiar estimates are made to account for managed burning of forest areas. Average emission factors were applied to the quantities of materials burned to calculate emissions.

3.5.2 Agricultural Burning

A study[18] was conducted by EPA to obtain from local agricultural and pollution control agencies estimates of the number of acres and estimated quantity of material burned per acre in agricultural burning operations. These data have been updated and used to estimate agricultural burning emissions, based on average emission factors.

3.5.3 Coal Refuse

Estimates of the number of burning coal-refuse piles existing in the United States are made in reports by the Bureau of Mines.[19] Their publication presents a detailed discussion of the nature, origin, and extent of this source of pollution. Rough estimates of the quantity of emissions were obtained using this information by applying average emission factors for coal combustion. It was assumed that the number of burning refuse piles decreased to a negligible amount by 1975.

3.5.4 Structural Fires

The United States Department of Commerce publishes, in their statistical abstracts, information on the number and types of structures damaged by fire.[20] Emissions were estimated by applying average emission factors for wood combustion to these totals.

3.5.5 Nonindustrial Organic Solvent Use

This category includes nonindustrial sales of surface coatings (primarily for architectural coating) solvent evaporation from consumer products (aerosols, space deodorants, polishes, toiletries, etc.), use of volatile organic compounds as general cleaning solvents, paint removers, and liquefaction of asphalt paving compounds, and other undefined end uses. Total national organic solvent use is estimated from chemical production reports of Reference 21, together with estimates of the portion of total production for use as solvent for each chemical.[15,29] It is assumed that all solvent production is equal to the amount necessary to make up for solvent lost through evaporation.

4. ANALYSIS OF TRENDS

National trends in air pollutant emissions are a function of a number of factors. Air pollution control measures and economic conditions have the strongest impact on total emissions. National emission trends do not provide any insight into the distribution or concentration of air pollution sources within the United States. Therefore, local emission trends do not necessarily coincide with national emission trends. Based on the national implementation of control measures for some classes of sources, such as highway motor vehicles, it is reasonable to infer that for most localities, the national trend in emissions reasonably approximates local trends in emissions for the same class of sources.

In addition to the fact that national emission trends do not measure local changes in emission densities, national emission trends may not be consistent with air quality trends because of the impact of meteorological factors on air quality data. Also, the estimates for PM, SOx, and NOx emissions include more substances than are routinely measured by ambient air monitoring equipment. For example, high-volume air samplers collect only suspended particulates approximately 0.3 to 100 micro-meters in diameter, but particulate emission inventories include both suspended and settled particulates generated by man's activities. Likewise, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) ambient air monitors measure only those two compounds while oxides of sulfur (SOx) and nitrogen (NOx) are included in the emission estimates. In each case, the substance measured by the ambient air monitor is the most prevalent constituent of its pollutant class or is acknowledged to be its most representative indicator. In this report, emissions of sulfur oxides are reported as the equivalent weight of SO_2, which is the predominant sulfur oxide species. Some emissions of sulfur trioxide (SO_3) are also included, expressed at the equivalent weight of SO_2. Similarly, nitrogen oxides include predominantly nitric oxide (NO) and nitrogen dioxide (NO_2). Other nitrogen oxides are probably emitted in small amounts. In this report all nitrogen oxide emissions are expressed as the equivalent weight of NO_2. Estimates of oxidant emissions are not provided because most oxidant species are secondary pollutants generated by photochemical reactions in the atmosphere. Emission estimates of VOC, a major ingredient in oxidant-producing reactions, were developed from current emission factors.[2,3] Generally excluded from VOC estimates were emissions of methane, ethane, methyl chloroform, and other compounds which are considered to be of neglible photochemical reactivity. Organic species were identified based on Reference 22. If no data were available for a source category, the total nonmethane hydrocarbon or the total hydrocarbon emission factor from Reference 2 was used. Highway vehicle emissions were estimated as nonmethane VOC's.[3]

The following sections discuss the most important factors influencing the emission trends for each pollutant.

4.1 Particulates

1940-1970

The estimated particulate emissions for 1940, 1950 and 1960 are 15 to 30 percent higher than in 1970. Even though industrial production levels and the quantities of fuels consumed were lower than the post-1970 period, the general lack of air pollution controls before 1970 resulted in relatively large particulate emissions. Also, for the years 1940 and 1950, particulate emissions from coal combustion by railroads and from forest wildfires were significant.

A large portion of the particulate emissions from stationary source fuel combustion, result from the combustion of coal. In 1940, coal was consumed largely in the industrial and residential sectors. Residential coal use has declined substantially since 1940, resulting in a corresponding reduction in emissions. Industrial coal use has also declined, but not to the same extent. The degree of control employed by industrial coal consumers has increased, however, so that overall industrial coal combustion emissions decreased by 1970 to only about 40 percent of the estimated 1940 level. On the other hand, coal combustion by electric utilities has increased greatly, from an estimated 51 million tons in 1940 to 321 million tons in 1970. This increased consumption resulted in increased emissions from 1940 to 1950. Since then, particulate emissions from electric utilities have decreased, despite continued increases in coal consumption. Installation of improved control equipment is responsible for this reduction.

Particulate emissions from industrial processes increased from 1940 to 1950, reflecting increased industrial production. From 1950 to 1970, industrial output continued to grow, but installation of pollution control equipment helped to offset the increase in industrial production. As a result, from 1950 to 1960 industrial process emissions stayed about the same, and decreased slightly from 1960 to 1970.

1970-1983

Since 1970, particulate emissions have decreased substantially as the result of air pollution control efforts. The extent of the reduction is most evident from the data in Table 29 which shows theoretical 1983 national emission estimates, assuming that pollutant control levels did not change since 1970. Overall, particulate emissions would have increased by about 7 percent from 1970 to 1983 with no change in the degree of control from 1970. In comparison, as shown in Table 1, particulate emissions decreased about 62 percent from 1970 to 1983. Thus, 1983 actual particulate emissions were about a third of what they might have been without additional control efforts since 1970.

A large portion of the particulate emissions from stationary source fuel combustion result from the combustion of coal. In 1970, a larger portion of coal was consumed in the industrial and residential sectors.

Residential coal use has declined substantially since 1970, resulting in a corresponding reduction in emissions. Industrial coal use has also declined, but not to the same extent. The degree of control employed by industrial coal consumers has increased, however, so that overall industrial coal combustion emissions have decreased by 1983 to only about 16 percent of the estimated 1970 level. On the other hand, coal combustion by electric utilities has increased greatly, from an estimated 321 million tons in 1970 to 625 million tons in 1983. However, particulate emissions from electric utilities have decreased, despite continued increases in coal consumption. Installation of improved control equipment is responsible for this reduction. New facilities constructed in the 1970's were required to meet New Source Performance Standards (NSPS) requirements to achieve a high degree of control. From Tables 2 and 29, it can be seen that if the 1970 level of control had remained in effect in 1983, electric utility emissions would have nearly doubled, from 2.3 teragrams to 4.6 teragrams. Estimated actual 1983 emissions from electric utilities were 0.5 teragrams, a decrease of 78 percent from 1970.

Particulate emissions from industrial processes have been reduced substantially due to installation of improved control equipment mandated by air pollution control programs. Since 1970, actual emissions from industrial processes declined by over 77 percent. If the 1970 control level had remained unchanged to 1983, emissions would have decreased only about 14 percent. It should be noted that industrial production levels for many sectors in 1983 were significantly lower than in the previous few years, reflecting poor economic conditions. This down-turn in industrial production also contributes to a decreased level of emissions relative to 1970. Table 23 shows estimated emissions for specific processes. These annual emissions estimates reflect changes in production levels along with an increase in average control levels from 1970 to 1983.

Comments on Particulate Emission Estimates

Caveats that should be noted with respect to these particulate emission estimates are first that the estimates represent total particulate emissions, without any distinction of particle sizes. Thus, both large particles and small particles are included. Emissions of very large particles are more likely to settle out of the atmosphere and not be measured as total suspended particulate by air quality monitoring equipment. Small and intermediate size particles are more likely to remain airborne and are more efficiently captured by total suspended particulate air monitoring equipment. Small particles are also capable of being inhaled into the human respiratory system, possibly causing adverse health effects. The particulate emission controls that have been employed to date have been most effective in reducing emissions of large and intermediate size particles. The trend in the emissions of small particles is not clearly known. It is very doubtful whether small particle emissions have been reduced to the extent that total particulate emissions have been reduced, however. It should be noted

that some small particles may be formed in the atmosphere as the result of various chemical and physical processes. Such particles are not included in the estimated total particulate emissions. A second caveat is that fugitive particulate (emissions from unconfined sources such as storage piles, material loading, etc.) emissions are incompletely accounted for in the emission totals. Rough estimates of industrial process fugitive emissions are included for some industries. Area source fugitive dust emissions (unpaved roads, construction activities, etc.) are not included at all. Similarly, natural sources of particulates, such as wind erosion or dust, are not included. (An exception is forest fires, some of which result from natural causes). In total, these fugitive emissions may amount to a considerable portion of total particulate emissions. The controls applied to these sources have so far been minimal. Due to the lack of adequate emission factors and emission inventory techniques for these sources, fugitive particulate emissions have not been included in most emission inventories. As additional data become available, it is expected that estimates of fugitive particulate emissions will be included in future emission inventories. It should be noted, however, that a major portion of the fugitive particulate emissions are relatively large particles that are not readily captured by particulate air quality monitors. Similarly, these large particles do not effectively enter into the human respiratory system.

4.2 Sulfur Oxides

1940-1970

From 1940 to 1970, major increases in sulfur oxide emissions occurred as the result of increased combustion of fossil fuels such as coal and oil. Industrial process emissions also increased, but to a lesser extent. Sulfur oxide emissions from other source categories decreased, primarily as the result of the obsolescence of coal-fired railroad locomotives and a decrease in coal refuse burning.

1970-1983

Since 1970, total sulfur oxide emissions have declined about 26 percent as the result of use of fuels with lower average sulfur contents, some scrubbing of sulfur oxides from flue gases, and controls on industrial process sources. Significant emission reductions from industrial processes have occurred, mostly from non-ferrous smelters and sulfuric acid plants. By-product recovery of sulfuric acid at smelters has increased since 1970. As a result, sulfur oxide emissions that previously would have been released to the atmosphere are recovered as sulfuric acid. Since 1972, new sulfuric acid manufacturing plants have been subject to New Source Performance Standards requirements. These rules have contributed to decreased emissions, as new plants built to meet new product demands or replace old facilities, must meet more stringent emission limitations than old facilities.

As shown in the tables, since 1970 sulfur oxide emissions from electric utilities account for more than half of the total emissions. Combustion of sulfur-bearing fuels, chiefly coal and residual fuel oil, is responsible. Between 1970 and 1983, utility use of coal increased by about 95 percent. Emissions from utilities have decreased, however, because fuels with lower sulfur content have been used to the extent that they were available. Also, flue gas desulfurization systems have been installed so that by the late 1970's enough units were in service to prevent increases in electric utility emissions. 1983 electric utility emissions would have been approximately 15 percent higher without the operation of flue gas desulfurization controls. The theoretical 1983 national emission estimates given in Table 29 for stationary fuel combustion sources are based on 1983 fuel amounts but fuel sulfur contents that represent 1970 average levels for fuel oil and an estimated average sulfur content of coal that would have been consumed if there were no changes in air pollution regulations since 1970. It is estimated that the national average sulfur content of coal burned would have declined anyway even without new air pollution regulations due to the greater use of coal from the Western U.S., which generally has a lower sulfur content than coal from the Eastern States. On this basis, electric utility emissions would have increased 24 percent. In fact, emissions decreased by 11 percent. Sulfur oxide emissions from other fuel combustion sectors decreased, primarily due to less coal burning by these industrial, commercial and residential consumers.

Comments on Sulfur Oxide Emission Estimates

Emissions of sulfur and nitrogen oxides have been identified as precursors of acidic precipitation and deposition. To support Federal research activities on the subject, more detailed historical emissions estimates of sulfur and nitrogen oxides have been developed. Interested readers may wish to review Reference 30, which contains State level estimates of sulfur and nitrogen oxide emissions from 1900 through 1980.

4.3 Nitrogen Oxides

1940-1970

Nitrogen oxide emissions result almost entirely from fuel combustion by stationary sources and motor vehicles. From 1940 through 1970, NOx emissions increased steadily as the result of increased fuel combustion.

1970-1983

Controls applied to sources of NOx emissions have had a limited effect in reducing emissions through 1983. Table 29 shows that with the 1970 control level, national NOx emissions would have been only 18 percent higher than actual 1983 emissions. The emissions from stationary fuel

combustion sources largely reflect the actual growth in fuel consumption. For electric utilities, NSPS control requirements have held down the growth in NOx emissions somewhat. Nevertheless, NOx emissions from electric utilities increased 40 percent from 1970 to 1983. For mobile sources, NOx emissions were controlled as a result of the Federal Motor Vehicle Control Program (FMVCP). Nitrogen oxide emissions from highway vehicles would have increased 57 percent, had there been no change in control level since 1970. The estimates of actual NOx emissions show a 17 percent increase.

4.4 Volatile Organic Compounds

1940-1970

From 1940 through 1970, VOC emissions increased about 50 percent. Major increases in highway vehicle travel and industrial production were chiefly responsible. Emissions from these source categories were about two and a half times higher in 1970 than in 1940. Emissions from residential fuel combustion and forest fires declined substantially, however. In 1940, residential fuel combustion and forest fires accounted for 40 percent of total national VOC emissions. By 1970, their contribution to total VOC emissions had been reduced to 6 percent.

1970-1983

Since 1970, emissions of VOC decreased primarily due to motor vehicle controls and less burning of solid waste. Had controls not been implemented, a substantial increase in emissions from highway vehicles would have occurred. From 1970 to 1983, vehicle-miles of travel in the U.S. increased by about 47 percent.[4] A comparable increase in emissions would have occurred had 1970 control levels remained unchanged. As a result of the controls put in place, VOC emissions from highway vehicles actually decreased 46 percent. VOC emissions also decreased due to the substitution of water-based emulsified asphalts (used for road paving) for asphalts liquefied with petroleum distillates (cutback asphalts). This is reflected in the decreased emissions reported for miscellaneous organic solvent use.

Through 1978 these decreases were offset by increases in industrial process emissions. Since then, industrial process emissions have also declined, so that overall total VOC emissions were reduced about 26 percent from 1970 to 1983. Industrial process emissions increased due to higher production levels, particularly in industrial sectors such as petroleum refining, organic chemical production, and industrial uses of organic solvents. Control procedures employed were effective in limiting the growth in emissions, however. In addition, source production levels in 1980 through 1983 were relatively low due to poor economic conditions. Through the mid-1970's, emissions from petroleum product storage and marketing operations also increased as the result of increased demand for petroleum products, particularly motor gasoline.

Since 1978, emissions from this source sector are estimated to have decreased as the result of declining product demand and more effective control measures.

In 1970, VOC emissions from residential fuel combustion were insignificant. However, in the late 1970's emissions began to increase due to the popularity of wood stoves and fireplaces for residential space heating. In 1983, residential fuel combustion accounted for about 10 percent of total VOC emissions.

Comments on VOC Emission Estimates

Volatile organic compounds along with nitrogen oxides are participants in atmospheric chemical and physical processes that result in the formation of ozone and other photochemical oxidants. Emissions of VOC that are most likely to have a role in such atmospheric processes are included in the reported emissions estimates. Photochemically non-reactive compounds such as methane are not included in the estimated emissions of VOC. Biogenic sources of organic compounds such as trees and other vegetation are not included either. Initial estimates are that emissions of VOC from naturally-occurring sources exceed the amount of anthropogenic emissions. The extent to which biogenic sources of VOC contribute to oxidant formation, if at all, has not been clearly established, however. Ambient concentrations of ozone are typically higher during the summer months. As a result, analysis of seasonal, rather than annual VOC emissions may be more appropriate to understand the relationship between VOC emissions and high ozone concentrations in the atmosphere. Sources such as residential space heating, which occurs primarily during the winter would have little impact on summer ozone levels.

4.5 Carbon Monoxide

1940-1970

From 1940 through 1970, the relative contribution by the various source categories to total CO emissions changed considerably. In 1940, highway vehicles contributed only about 28 percent of carbon monoxide emissions. Residential fuel combustion (primarily of wood and coal), forest fires and other burning (agricultural crop residues and coal refuse) contributed about 50 percent of total CO emissions. From 1940 to 1970, highway vehicle emissions nearly tripled, while emissions from residential fuel combustion and miscellaneous burning sources decresed substantially. As a result, in 1970 highway vehicles accounted for 64 percent of total CO emissions. Industrial process CO emissions increased from 1940 to 1970 by about 36 percent. The largest increase occurred in the petroleum refining sector, primarily as the result of expansion of catalytic cracking capacity to meet increased demand for gasoline and other middle distillates.

1970-1983

Since 1970, highway motor vehicles have been the largest contributing source of CO emissions. The implementation of the Federal Motor Vehicle Control Program (FMVCP) has been successful in reducing CO emissions since the early 1970's. From 1970 through 1978, motor vehicle miles of travel increased 38 percent, but because of controls on new vehicles, total CO emissions from highway vehicles decreased 16 percent. From 1978 to 1980, VMT declined by 1.7 percent. Since 1980, growth in VMT has resumed, similar to the growth rate that occurred in the 1970's. Overall, from 1978 to 1983, VMT grew by only 6.5 percent, however. This lack of growth in vehicle travel together with an increased degree of control because of stricter emission standards for new vehicles and the gradual disappearance of older uncontrolled vehicles from the vehicle fleet, produced an estimated 22 percent drop in highway vehicle emissions in the four year period from 1978 to 1982. Overall from 1970 to 1983, without the implementation of FMVCP, highway vehicle emissions would have increased 34 percent. By comparison, actual emissions are estimated to have decreased 34 percent.

CO emissions from other sources have also generally decreased. In 1970, emissions from burning of agricultural crop residues were greater than in more recent years. Solid waste disposal emissions have also decreased as the result of implementation of regulations limiting or prohibiting burning of solid waste in many areas. Emissions of CO from stationary source fuel combustion occur mainly from the residential sector. These emissions were reduced somewhat through the mid-1970's as residential consumers converted to natural gas, oil, or electric heating equipment. Recent growth in the use of residential wood stoves has reversed this trend, but increased CO emissions from residential sources continue to be small compared to highway vehicle emissions. Nevertheless, in 1983 residential wood combustion accounted for about 9 percent of national CO emissions, more than any source category except highway vehicles. CO emissions from industrial processes have generally been declining since 1970 as the result of the obsolescence of a few high polluting processes such as manufacture of carbon black by the channel process and installation of controls on other processes.

4.6 Lead

1970-1983

The emissions of lead have decreased due to the implementation of the Federal Motor Vehicle Control Program (FMVCP). The implementation of FMVCP has resulted in the use of catalytic converters to reduce NOx, VOC, and CO emissions and has required the use of unleaded gasoline for vehicles with converters. From 1970 through 1974, the highway use of gasoline increased 13 percent, but because of the decrease in lead content in leaded gasoline, lead emissions from highway vehicles decreased 17 percent. From 1975 to 1983, the percent unleaded gasoline

sales increased from 13 to 55 percent, and the lead emissions decreased 67 percent. From 1970 through 1983, off highway consumption of gasoline decreased 44 percent while lead emissions decreased 74 percent.

Lead emissions also decreased from other sources. The 94 percent decrease in stationary source fuel combustion is a result of the decrease in lead concentration in waste oil utilized in industrial boilers. Lead emissions decreased 90 percent for industrial processes from 1970 through 1983. Part of this decrease reflects the changes that result from installation of air pollution control equipment. As shown in Tables 12 and 29, the change in emissions as a result of changes in operating rates would be a 32 percent reduction. Lead emissions from solid waste disposal have decreased 84 percent from 1970 through 1983 as a result of the decreased amount of solid waste disposed of by incineration.

TABLE 29

THEORETICAL 1983 NATIONAL EMISSION ESTIMATES
BASED ON 1970 LEVEL OF CONTROL
(TERAGRAMS/YEAR)

Source Category	PM	SO_2	NO_x	HC	CO	Pb[1]
Transportation						
Highway Vehicles	1.4	0.5	9.4	15.7	83.9	181.2
Non-Highway	0.2	0.4	1.8	1.2	6.6	4.3
Transportation Total	1.6	0.9	11.2	16.9	90.5	185.5
Stationary Source Fuel Combustion						
Electric Utilities	4.6	19.6	7.1	0.0	0.3	0.5
Industrial	1.1	2.1	2.8	0.1	0.6	9.2
Residential/Commercial	1.1	0.7	0.6	2.0	6.1	0.0
Fuel Combustion Total	6.8	22.4	10.5	2.1	7.0	9.7
Industrial Processes (SIC)						
Mining Operations (10,2,13,14)	3.3	0.4	0.0	0.0	0.0	0.2
Food and Agriculture (02,07,20)	0.9	0.0	0.0	0.2	0.0	0.0
Wood Products (24,26)	0.7	0.1	0.0	0.0	0.7	0.0
Chemicals (28)	0.2	0.7	0.2	2.0	2.6	0.4
Petroleum Refining (29)	0.1	0.9	0.2	1.0	2.0	0.0
Mineral Products (32)	2.6	0.7	0.2	0.0	0.0	0.5
Metals (33)	1.1	2.5	0.0	0.0	2.2	15.1
Miscellaneous	0.0	0.0	0.0	5.6	0.0	0.1
Industrial Processes Total	8.7	5.3	0.6	9.0	7.3	16.3
Solid Waste	1.2	0.1	0.4	2.0	7.0	1.3
Miscellaneous	0.9	0.0	0.2	3.3	6.3	0.0
Total	19.2	28.7	22.9	33.3	118.1	214.8
1983 Actual Emissions (Table 1)	6.9	20.8	19.4	19.9	67.6	46.9
Theoretical 1983 Emissions As A Percentage Of 1983 Actual Emissions	278%	138%	118%	167%	175%	458%
1970 Actual Emissions (Table 1)	18.0	28.2	18.1	27.0	98.3	203.8
Theoretical 1983 Emissions As A Percentage of 1970 Actual Emissions	107%	102%	127%	123%	120%	105%

[1]Lead emissions are expressed in gigagrams/year.

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16. ABSTRACT

This report presents estimates of trends in nationwide air pollutant emissions for the six major pollutants: sulfur oxides, particulates, carbon monoxide, volatile organic compounds, nitrogen oxides, and lead. Estimates are broken down according to major types of air pollutant sources. A short analysis of emission trends is given, along with a discussion of methods used to develop the data.

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